JC07 Rec'd PCT/PTO 27 APR 2001

FORM PTO-1390 (Modified) (REV 11-98) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
112740-198

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR
09/830624

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE99/03430	**October 27, 1999**	**October 27 1998**

TITLE OF INVENTION
METHOD FOR CONTROLLING MEMORY ACCESS IN RAKE RECEIVERS WITH EARLY/LATE TRACKING IN TELECOMMUNICATION SYSTEMS

APPLICANT(S) FOR DO/EO/US
Dr. Reinhold Bramm et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☒ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

Return Receipt Postcard

PCTUS1/REV03

JC18 Rec'd PCT/PTO 27 APR 2001

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/830624	**PCT/DE99/03430**	**112740-198**

21. The following fees are submitted:.

	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :		
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1,000.00**		
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but Internation Search Report prepared by the EPO or JPO **$860.00**		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**		
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**		
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$860.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$0.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	1 - 20 =	0	x $18.00	**$0.00**	
Independent claims	1 - 3 =	0	x $80.00	**$0.00**	
Multiple Dependent Claims **(check if applicable).**			☐	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$860.00**	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) **(check if applicable).** ☐				**$0.00**	
SUBTOTAL =				**$860.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				**$0.00**	
TOTAL NATIONAL FEE =				**$860.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☐				**$0.00**	
TOTAL FEES ENCLOSED =				**$860.00**	
				Amount to be: refunded	$
				charged	$

☒ A check in the amount of **$860.00** to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. in the amount of to cover the above fees. A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **02-1818** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

William E. Vaughan
NAME

39,056
REGISTRATION NUMBER

April 27, 2001
DATE

09/830624

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BOX PCT

IN THE UNITED STATES ELECTED/DESIGNATED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

PRELIMINARY AMENDMENT

APPLICANTS: Dr. Reinhold Braam et al.		DOCKET NO: 112740-198
SERIAL NO:		GROUP ART UNIT:
		EXAMINER:
INTERNATIONAL APPLICATION NO:		PCT/DE99/03430
INTERNATIONAL FILING DATE:		27 October 1999
INVENTION:	METHOD FOR MEMORY ACCESS CONTROL IN RAKE RECEIVERS WITH EARLY-LATE TRACKING IN TELECOMMUNICATIONS SYSTEMS	

Assistant Commissioner for Patents,
Washington, D.C. 20231

Sir:

Please amend the above-identified International Application before entry into the National stage before the U.S. Patent and Trademark Office under 35 U.S.C. §371 as follows:

In the Specification:

Please replace the Specification of the present application, including the Abstract, with the following Substitute Specification:

SPECIFICATION

TITLE

METHOD FOR MEMORY ACCESS CONTROL IN RAKE RECEIVERS WITH EARLY-LATE TRACKING IN TELECOMMUNICATIONS SYSTEMS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates, generally, to a method for memory access control in RAKE receivers with early-late tracking in telecommunication systems with wire-free telecommunication between mobile and/or stationary transceivers, and, more particularly, to such a method wherein the number of memory accesses is less than with previously known methods.

Description of the Prior Art

Telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers are specific message systems with a message transmission path between a message source and a message sink, in which, for example, base stations and mobile parts are used as transmitters and receivers for message processing and transmission, and in which:

1) the message processing and message transmission can take place in one preferred transmission direction (simplex operation) or in both transmission directions (duplex operation);

2) the message processing is preferably digital; and

3) the messages are transmitted via the long-distance transmission path without wires based on various message transmission methods FDMA (**F**requency **D**ivision **M**ultiple **A**ccess), TDMA (**T**ime **D**ivision **M**ultiple **A**ccess) and/or CDMA (**C**ode **D**ivision **M**ultiple **A**ccess) - for example in accordance with radio standards such as DECT [**D**igital **E**nhanced (previously: **E**uropean) **C**ordless **T**elecommunication; see *Nachrichtentechnik Elektronik* [Information Technology

Electronics] *42 (1992) Jan./Feb. No. 1, Berlin, DE; U. Pilger "Struktur des DECT-Standards" [Structure of the DECT Standard], pages 23 to 29* **in conjunction with** ETSI Publication *ETS 300175-1 ... 9, October 1992* and the DECT Publication from the *DECT Forum, February 1997, pages 1 to 16]*, GSM [**G**roupe **S**péciale **M**obile or **G**lobal **S**ystem for **M**obile Communication; see *Informatik Spectrum* [Information Technology Spectrum] *14 (1991) June No. 3, Berlin, DE; A. Mann: "Der GSM-Standard - Grundlage für digitale europäische Mobilfunknetze" [The GSM Standard - Basis of digital European mobile networks], pages 137 to 152* **in conjunction with** the publication *telekom praxis 4/1993, P. Smolka "GSM-Funkschnittstelle - Elemente und Funktionen" [Telecommunications in practice] [GSM radiointerface - Elements and functions] Pages 17 to 24]* UMTS [**U**niversal **M**obile **T**elecommunication **S**ystem; see **(1)**: *Nachrichtentechnik Elektronik [Information Technology Electronics], Berlin 45, 1995, issue 1, pages 10 to 14 and issue 2, pages 24 to 27; P. Jung, B. Steiner: "Konzept eines CDMA-Mobilfunksystems mit gemeinsamer Detektion für die dritte Mobilfunkgeneration" [Concept of a CDMA mobile radio system with joint detection for third-generation mobile radios]*; **(2):** *Nachrichtentechnik Elektronik [Information Technology Electronics], Berlin 41, 1991, issue 6, pages 223 to 227 and page 234; P.W. Baier, P. Jung, A. Klein: "CDMA - ein günstiges Vielfachzugriffsverfahren für frequenzselektive und zeitvariante Mobilfunkkanäle" [CDMA - a suitable multiple access method for frequency-selective and time-variant mobile radio channels]*; **(3)**: *IEICE Transactions on*

Fundamentals of Electronics, Communications and Computer Sciences, Vol. E79-A, No. 12, December 1996, pages 1930 to 1937; P.W. Baier, P. Jung: "CDMA Myths and Realities Revisited"; **(4)**: *IEEE Personal Communications, February 1995, pages 38 to 47; A. Urie, M. Streeton, C. Mourot: "An Advanced TDMA Mobile Access System for UMTS"*; **(5)**: *telekom praxis [Telecommunications practice], 5/1995, pages 9 to 14; P.W. Baier: "Spread-Spectrum-Technik und CDMA - eine ursprünglich militärische Technik erobert den zivilen Bereich" [Spread spectrum technology and CDMA - an originally military technology taking over the civil market]* **(6)**: *IEEE Personal Communications, February 1995, pages 48 to 53; P.G. Andermo, L.M. Ewerbring: "A CDMA-Based Radio Access Design for UMTS";* **(7)**: *ITG Fachberichte [ITG Specialist Reports] 124 (1993), Berlin, Offenbach: VDE Verlag ISBN 3-8007-1965-7, pages 67 to 75; Dr. T. Zimmermann, Siemens AG: "Anwendung von CDMA in der Mobilkommunikation" [Use of CDMA in mobile communication];* **(8)**: *telcom report 16, (1993), issue 1, pages 38 to 41: Dr. T. Ketseoglou, Siemens AG and Dr. T. Zimmermann, Siemens AG: "Effizienter Teilnehmerzugriff für die 3. Generation der Mobilkommunikation - Vielfachzugriffsverfahren CDMA macht Luftschnittstelle flexibler" [Efficient subscriber access for third-generation mobile communication - the CDMA multiple access method makes the air interface more flexible];* **(9)**: *Funkschau 6/98: R. Sietmann "Ringen um die UMTS-Schnittstelle" [Fierce competition for the UMTS interface], pages 76 to 81]* WACS or PACS, IS-54, IS-95, PHS, PDC

etc. [see IEEE Communications Magazine, January 1995, pages 50 to 57; D.D. Falconer et al: "Time Division Multiple Access Methods for Wireless Personal Communications"]. "Message" is a generic term which covers both the content (information) and the physical representation (signal). Despite a message having the same content that is to say the same information, different signal forms can occur. Thus, for example, a message relating to an item may be transmitted

(1) in the form of an image,

(2) as a spoken word,

(3) as a written word, or

(4) as an encrypted word or image.

Transmission types (1) ... (3) are in this case normally characterized by continuous (analog) signals, while transmission type (4) normally uses discontinuous signals (for example pulses, digital signals).

According to the document Funkschau 6/98: R. Sietmann "Ringen um die UMTS-Schnittstelle" [Fierce competition for the UMTS interface], pages 76 to 81, for example, there are two scenario elements in the UMTS scenario (third-generation mobile radio or IMT-2000). In the first scenario element, the licensed coordinated mobile radio is based on a WCDMA technology (**W**ideband **C**ode **D**ivision **M**ultiple **A**ccess) and, as in the case of GSM, is operated using the FDD mode (**F**requency **D**ivision **D**uplex), while, in the second scenario element, the unlicensed uncoordinated mobile radio is based on a TD-CDMA technology

(**T**ime **D**ivision-**C**ode **D**ivision **M**ultiple **A**ccess) and, like DECT, is operated in the TDD mode (**F**requency **D**ivision **D**uplex).

For WCDMA/FDD operation of the Universal Mobile Telecommunications System, the air interface of the telecommunications system, in each case, contains a number of physical channels in the uplink and downlink telecommunications directions, according to the document ETSI STC SMG2 UMTS-L1, Tdoc SMG2 *UMTS-L1 163/98: "UTRA Physical Layer Description FDD Parts" Vers. 0.3, 1998-05-29* of which a first physical channel, the so-called **D**edicated **P**hysical **C**ontrol **Ch**annel DPCCH, and a second physical channel, the so-called **D**edicated **P**hysical **D**ata **Ch**annel DPDCH, are illustrated in Figures 1 and 2 related to their time frame structures.

In the downlink direction (radio link from the base station to the mobile station) in the WCDMA/FDD system from ETSI and ARIB, the dedicated physical control channel (DPCCH) and the Dedicated Physical Data Channel (DPDCH) are time-division multiplexed, while I/Q multiplexing is used in the uplink direction, for which the DPDCH is transmitted in the I-channel and the DPCCH in the Q-channel.

The DPCCH contains N_{pilot} pilot bits for channel estimation, N_{TPC} bits for fast power control and N_{TFI} format bits, which indicate the bit rate, the nature of the service, the nature of the error protection coding, etc. (TFI = Traffic Format Indicator).

Based on a GSM radio scenario with, for example, two radio cells and base stations (**B**ase **T**ransceiver **S**tation) arranged in them, with a first base station BTS1 (transmitter/receiver) "illuminating" a first radio cell FZ1 and a second base station BTS2 (transmitter/receiver) "illuminating" a second radio cell FZ2 omnidirectionally, Figure 3 shows a FDMA/TDMA/CDMA radio scenario, in which the base stations BTS1, BTS2 are connected or can be connected via an air interface, which is designed for the FDMA/TDMA/CDMA radio scenario, to a number of mobile stations MS1...MS5 (transmitter/receiver) located in the radio cells FZ1, FZ2, on appropriate transmission channels TRC via wire-free unidirectional or bidirectional (uplink direction UL and/or downlink direction DL) telecommunication. The base stations BTS1, BTS2 are connected in a known manner (see GSM telecommunication system) to a base station controller BSC (**B**ase **S**tation **C**ontroller) which carries out the frequency management and switching functions in the course of controlling the base stations. For its part, the base station controller BSC is connected via a mobile switching center MSC to the higher-level telecommunications network, for example to the PSTN (Public Switched Telecommunication Network. The mobile switching center MSC is the management center for the illustrated telecommunication system. It carries out all call management functions and, using attached registers (not illustrated), authentication of the telecommunications subscribers and position monitoring in the network.

Figure 4 shows the basic structure of the base station BTS1, BTS2, which are in the form of transmitters/receivers, while Figure 5 shows the basic structure of the mobile stations MT1...MT5, which are likewise in the form of transmitters/receivers. The base stations BTS1, BTS2 transmit and receive radio messages from and to the mobile stations MTS1...MTS5, while the mobile stations MT1...MT5 transmit and receive radio messages from and to the base stations BTS1, BTS2. To this end, the base stations have a transmitting antenna SAN and a receiving antenna EAN, while the mobile stations MT1...MT5 have a joint antenna ANT for transmission and reception, which can be controlled by an antenna switch AU. In the uplink direction (receiving path), the base stations BTS1, BTS2 receive via the receiving antenna EAN, for example, at least one radio message FN with an FDMA/TDMA/CDMA component from at least one of the mobile stations MT1...MT5, while the mobile stations MT1...MT5 receive in the downlink direction (receiving path), via the common antenna ANT, for example at least one radio message FN with an FDMA/TDMA/CDMA component from at least one base station BTS1, BTS2. The radio message FN in this case includes a broadband-spread carrier signal with information composed of data symbols modulated onto it.

In a radio receiving device FEE (receiver), the received carrier frequency is filtered and is mixed down to an intermediate frequency which, for its part, is then sampled and quantized. After analog/digital conversion, the signal, which has been subject to distortion on the radio path due to multipath propagation, is

supplied to an equalizer EQL, which compensates for the majority of the distortion (keyword: synchronization).

A channel estimator KS is then used to attempt to estimate the transmission characteristics of the transmission channel TRC on which the radio message FN has been transmitted. The transmission characteristics of the channel are, in this case, indicated by the channel input response in the time domain. In order to allow the channel impulse response to be estimated, the radio message FN is allocated or assigned at the transmission end (in the present case by the mobile stations MT1...MT5 or the base stations BTS1, BTS2) specific additional information, which is in the form of a training information sequence and is referred to as a midamble.

In a data detector DD following this and which is used jointly for all the received signals, the individual mobile-station-specific signal elements contained in the common signal are equalized and separated in a known manner. After equalization and separation, a symbol-to-data converter SDW is used to convert the data symbols obtained so far to binary data. After this, a demodulator DMOD is used to obtain the original bit stream from the intermediate frequency before, in a demultiplexer DMUX, the individual timeslots are allocated to the correct logical channels, and thus also to the various mobile stations.

The received bit sequence is decoded channel-by-channel in a channel codec KC. Depending on the channel, the bit information is assigned to the monitoring and signaling timeslots or to a voice timeslot and, in the case of the

base station (Figure 4), the monitoring and signaling data and the voice data are passed jointly to an interface SS, which is responsible for the signaling and the voice coding/decoding (voice codec) for transmission to the base station controller (BSC). In the case of the mobile station (Figure 5) - ,the monitoring and signaling data are passed to a control and signaling unit STSE which is responsible for all the signaling and control of the mobile station, and the voice data are passed to a voice codec SPC designed for voice inputting and outputting.

In the voice codec in the interface SS in the base stations BTS1, BTS2, the voice data is in a predetermined data stream (for example, 64kbps stream in the network direction and 13kbps stream from the network direction).

All the control for the base stations BTS1, BTS2 is carried out in a control unit STE.

In the downlink direction (transmission path), the base stations BTS1, BTS2 transmit via the transmitting antenna SAN, for example, at least one radio message FN with an FDMA/TDMA/CDMA component to at least one of the mobile stations MT1...MT5, while the mobile stations MT1...MT5 transmit in the uplink direction (transmission path) via the common antenna ANT, for example, at least one radio message FN with an FDMA/TDMA/CDMA component to at least one base station BTS1, BTS2.

In Figure 4, the transmission path starts in the base stations BTS1, BTS2 in such a way that monitoring and signaling data received in the channel codec KC from the base station controller BSC via the interface SS, together with voice

data are assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

In Figure 5, the transmission path starts in the mobile stations MT1...MT5 in such a manner that voice data received in the channel codec KC from the voice coder SPC and monitoring and signaling data received from the control and signaling unit STSE are assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

The bit sequence obtained in the base stations BTS1, BTS2 and in the mobile stations MT1...MT5 is, in each case, converted in a data-to-symbol converter DSW into data symbols. Following this, the data symbols are spread in a spreading device SPE using a respective subscriber-specific code. In the burst generator BG, including a burst former BZS and a multiplexer MUX, a training information sequence in the form of a midamble for channel estimation is then added to the spread data symbols in the burst former BZS and, in the multiplexer MUX, the burst information obtained in this way is set to the respective correct timeslot. Finally, the burst obtained is, in each case, radio-frequency modulated and is digital/analog converted in a modulator MOD, before the signal obtained in this way is transmitted as a radio message FN via a radio transmission device FSE (transmitter) at the transmitting antenna SAN or the common antenna ANT.

The problem of multiple reception, that is to say of "delay spreads", when echos are present can be solved in CDMA-based systems, despite the wide bandwidth and the very short chip or bit times in these systems, by the received

signals being combined with one another in order to increase the detection probability. The channel characteristics must, of course, be known in order to do this. These channel characteristics are determined using a pilot sequence (see: Figures 1 and 2) which is common to all subscribers and is additionally transmitted without modulation autonomously via a message sequence and with an increased transmission power. The receiver uses its reception to obtain the information as to how many paths are involved in the present reception situation, and what delay times are occurring in the process.

In a RAKE receiver, the signals arriving via the individual paths are detected in separate receivers, the "fingers" of the RAKE receiver, and are added up, with different weightings to one another, in an addition element after compensation for the delay times and the phase shifts of the echos.

The fingers of the RAKE receiver can be readjusted depending on the change in the transmission channel with the aid of an early and late tracking method (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 6.3) without having to carry out any further time-consuming and resource-intensive channel estimation. To do this, two additional fingers are, in each case, added to each RAKE finger as shown in Figure 6. The two fingers detect the received signal r(t) with the same spread code s(t) as the main finger, the only difference to the main finger being that the received signal in the early finger is advanced by one position, and that in the late finger is delayed by one sample position. This method can be used, in particular, in the

case of oversampling. The energies collected from the early and late fingers are compared. The finger position of the main finger is shifted in the direction of the stronger finger after this comparison. This is done only when the energy difference exceeds a specific threshold value. The RAKE receiver is described in more detail in the cited literature (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 14.5).

It can be seen from Figure 6 that the early finger carries out the despreading process for the received signal one delay unit earlier than the actual main finger. The late finger carries out the despreading process precisely one delay unit later than the main finger.

Figure 7 shows the formation of a finger. This includes essentially two multipliers MUL and an accumulation unit AE. Each sampled received value r(t) is multiplied by the spread code s(t) and is weighted with the weighting gw in accordance with a channel estimate, this weighting gw being different for each finger in a RAKE receiver.

The values calculated in this way are now added up in accordance with the spread factor. The result for each finger is a complex signal, which represents a despread symbol. In the early and late fingers, multiplication by the weighting can be omitted, that is to say the weighting is unity. All the signals illustrated in Figures 6 and 7 are complex, and thus include both a real part and an imaginary part. The results obtained from the early and late fingers are evaluated by forming the magnitude, and subsequent comparison of the magnitude. If the magnitudes

differ significantly, that is to say they have a minimum difference, which is defined by a value TH, the position of the fingers is varied such that the main finger is located in the position with the greater energy after the change.

This is illustrated in Figure 8. The energy which the early finger calculates, in the stage denoted by P_E, is compared with the energy P_L calculated by the late finger. This is done simply on the basis of evaluation of the energy difference between the two fingers. In the first case, the fingers are not shifted, since the difference between the early and late energy is not particularly large; i.e., it is significantly less than the threshold value TH to be defined. In the second case, the difference between the early and late fingers is greater than TH, and the energy of the late finger is greater than the energy of the early finger. In consequence, the main finger is shifted by one delay stage to the rear. In the third case, the difference between the early and late fingers is likewise greater than TH and, this time, the energy of the early finger is greater than the energy of the late finger. In consequence, the main finger is shifted by one delay stage forward.

The problem described in the following text can occur when using early and late fingers in the rake receivers:

If, as shown in Figure 9, the received data is buffer-stored in an RAM memory SP, in order then to be passed on by appropriate memory accesses via a multiplexer MUX to the RAKE receiver, then three memory accesses must be carried out per RAKE finger. One access is, in each case, required for the main, the early and the late finger. If, for example, the data is written to the memory

using a 4 MHz sampling frequency, then that memory must be readable at 96 MHz if there are eight RAKE fingers. This ratio changes in the case of oversampling since, then, the data is written to the memory at a higher speed, corresponding to the oversampling rate.

Figure 9 shows a conventional circuit. The three RAKE fingers access the RAM memory SP independently of one another via the multiplexer MUX. The scrambling is reversed (descrambling), and path weighting is carried out in a known manner via a number of multipliers MUL in the RAKE receiver.

An object on which the present invention is based is to specify a method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/ receivers, in particular in third-generation mobile radio systems, in which the number of memory accesses is less than with the previously known methods.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a method wherein data which is received in the RAKE receiver and is read by an early finger in the early-late tracking is buffer-stored and is passed on one read cycle later to a late finger for reading by the same in the early-late tracking.

An idea on which the present invention is based is to make use of a characteristic which results from the ratio of the early and late data to one another. The data which is read by an early finger is read one read cycle later by the

corresponding late finger. It is thus sufficient to buffer-store data read by the early finger in a memory and to pass such data on appropriately to the late finger which then need no longer itself directly access the memory. If no oversampling is used, then it is even possible to replace all three memory accesses by just one. If the early and the late finger share one memory access, the total number of memory accesses is reduced by 1/3. The use of slower and, thus, more cost-effective memory modules is hence possible.

Additional features and advantages of the present invention are described in, and will be apparent from, the Detailed Description of the Preferred Embodiments and the Drawings.

DESCRIPTION OF THE DRAWINGS

Figures 1 and 2 show, for the WCDMA/FDD operation of the universal mobile telecommunication system, the Dedicated Physical Control Channel and the Dedicated Physical Data Channel of the air interface of a telecommunication system with respect to their framed structures;

Figure 3 shows, on the basis of the GSM radio scenario, first and second base transceiver stations;

Figure 4 shows the basic configuration of the base transceiver station constructed as a transceiver;

Figure 5 shows the basic configuration of the mobile station constructed as a transceiver;

Figure 6 shows the fingers of the RAKE receiver being readjusted wherein two additional fingers are added to each RAKE finger;

Figure 7 shows the formation of a finger including two multipliers and an accumulation unit;

Figure 8 illustrates the evaluation of the energy difference between the early and late fingers;

Figure 9 shows a conventional circuit wherein three RAKE fingers access the RAM memory independently of one another via a multiplexor; and

Figure 10 shows a modified version of the circuit shown in Figure 9 wherein one memory access can be saved in the case of memory accesses in a RAKE receiver.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Based on Figure 9, Figure 10 shows how one memory access can be saved in the case of memory accesses in a RAKE receiver.

Figure 10 shows a circuit modified from that in Figure 9. Two of the three RAKE fingers, the main finger and the early finger, once again access the RAM memory SP via the multiplexer MUX independently of one another. Once again, the scrambling is reversed (descrambling) and a path weighting is carried out in a known manner using a number of multipliers MUL in the RAKE receiver. In the case of access by the early finger for the early-late tracking, the data read from the RAM memory SP is buffer-stored in a buffer store (register) ZSP, and is passed

on one read cycle later to the late finger for reading by the same in the early-late tracking.

To assist understanding of the memory access process shown in Figure 10, this process will be described for the following access scenario, which relates to one finger. In the example, the oversampling rate is chosen to have a value "2", that is to say two samples per chip are stored in the memory SP.

The received signal is stored in the RAM memory SP at a sampling rate $T_c/2$, T_c is the time duration of a chip.

The read address is calculated from the path delay. Only data in the T_c frame are required for despreading the signal.

<u>Example</u>: Delay = 7* T_c, refers to the signal being delayed by 7 chips, and the first correct value is that in the 7th chip position.

Since two samples are stored per chip, the first sample must be read at the address "14 (14/2 = 7)".

The received signal is read starting from the address "14". The address counter then counts onwards in steps of 2. Addresses "14, 16, 18, 20, 22, 24 etc." are thus read. This applies to the main finger.

The early and late fingers require the signal delayed by half a chip and the signal that arrived half a chip earlier, respectively.

Thus, the addresses "13, 15, 17, 19, 21 etc." are read for the early finger, while the addresses "15, 17, 19, 21, 23 etc." are read for the late finger.

This can be done quite easily since the values in the $T_c/2$ frame are stored in the RAM memory SP so that the early address can be calculated from the main address minus 1, and the late address can be calculated from the main address plus 1.

The addresses "13, 14 and 15" therefore need to be read from the memory SP in the first step. The addresses "15, 16 and 17" are read in the second step, etc.

If the procedure used in the circuit shown in Figure 9 is used, then 3 memory accesses are required per calculation step; resulting in an access speed of 12 MHz for a 4 MHz signal. If the memory is now read simultaneously by 8 fingers, that is to say 8 early fingers, 8 late fingers and 8 main fingers, then access is required at 12*8 MHz = 96 MHz.

However, with this configuration, the memory location "15" is read in the second step, although it has already been used in the first step. One memory access per processing step is thus sufficient for the early and late fingers. The value for the late finger is obtained by delaying the value for the early finger by one chip. Thus, if the early finger reads the value "15", the output of the delay element for the late finger is first fed with the value "17". However, this results in the correct sequence for the various fingers.

The number of memory accesses can, thus, be reduced by 1/3 since the early and late fingers share one memory access. Slower and more cost-effective memory modules can then be used which, in turn, results in reduced power consumption.

Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

ABSTRACT OF THE DISCLOSURE

In order to control memory accesses in RAKE receivers having early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-generation mobile radio systems, such that the number of memory accesses is less than with previous known methods, data which is received in the RAKE receiver and is read by an early finger in the early-late tracking is buffer-stored and is passed on one read cycle later to a late finger for reading by the same in the early-late tracking.

In the claims:

Please cancel the sole Claim.

Please amend new Claim 2 as follows:

2. A method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between at least one of mobile and stationary transceivers, in third-generation mobile radio systems, the method comprising the steps of:

receiving data in the RAKE receiver;

reading the data by an early finger in the early-late tracking;

buffer-storing the data; and

passing on the data one read cycle later to a late finger for reading by the late finger in the early-late tracking.

REMARKS

The present amendment makes editorial changes and corrects typographical errors in the specification, which includes the Abstract, in order to conform the specification to the requirements of United States Patent Practice. No new matter is added thereby. Attached hereto is a marked-up version of the changes made to the specification by the present amendment. The attached page is captioned **"Version With Markings to Show Changes Made".**

In addition, the present amendment cancels the sole claim in favor of new claim 2. Claim 2 has been presented solely because the revisions by red-lining and underlining which would have been necessary in the sole claim in order to present those claims in accordance with preferred United States Patent Practice would have been too extensive, and thus would have been too burdensome. The present amendment is intended for clarification purposes only and not for substantial reasons related to patentability pursuant to 35 USC §§103, 102, 103 or 112.

Early consideration on the merits is respectfully requested.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In The Specification:

The specification of the present application, including the Abstract, has been amended as follows:

SPECIFICATION

TITLE

~~Method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-generation mobile radio systems~~

METHOD FOR MEMORY ACCESS CONTROL IN RAKE RECEIVERS WITH EARLY-LATE TRACKING IN TELECOMMUNICATIONS SYSTEMS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates, generally, to a method for memory access control in RAKE receivers with early-late tracking in telecommunication systems with wire-free telecommunication between mobile and/or stationary transceivers, and, more particularly, to such a method wherein the number of memory accesses is less than with previously known methods.

Description of the Prior Art

Telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers are specific message systems with a message transmission path between a message source and a message sink, in which, for example, base stations and mobile parts are used as transmitters and receivers for message processing and transmission, and in which:

1) the message processing and message transmission can take place in one preferred transmission direction (simplex operation) or in both transmission directions (duplex operation)~~,~~;

2) the message processing is preferably digital~~,~~; and

3) the messages are transmitted via the long-distance transmission path without wires based on various message transmission methods FDMA (**F**requency **D**ivision **M**ultiple **A**ccess), TDMA (**T**ime **D**ivision **M**ultiple **A**ccess) and/or CDMA (**C**ode **D**ivision **M**ultiple **A**ccess) - for example in accordance with radio standards such as DECT [**D**igital **E**nhanced (previously: **E**uropean) **C**ordless **T**elecommunication; see *Nachrichtentechnik Elektronik* [Information Technology Electronics] *42 (1992) Jan./Feb. No. 1, Berlin, DE; U. Pilger "Struktur des DECT-Standards" [Structure of the DECT Standard], pages 23 to 29* **in conjunction with** ETSI Publication *ETS 300175-1...9, October 1992* and the DECT Publication from the *DECT Forum, February 1997, pages 1 to 16]*, GSM [**G**roupe **S**péciale **M**obile or **G**lobal **S**ystem for **M**obile Communication; see *Informatik Spectrum* [Information Technology Spectrum] *14 (1991) June No. 3, Berlin, DE; A. Mann: "Der GSM-Standard - Grundlage für digitale europäische Mobilfunknetze" [The GSM Standard - Basis of digital European mobile networks], pages 137 to 152* **in conjunction with** the publication *telekom praxis 4/1993, P. Smolka "GSM-Funkschnittstelle - Elemente und Funktionen" [Telecommunications in practice] [GSM radiointerface - Elements and functions] Pages 17 to 24]* UMTS [**U**niversal **M**obile **T**elecommunication **S**ystem; see **(1)**:

Nachrichtentechnik Elektronik [Information Technology Electronics], Berlin 45, 1995, issue 1, pages 10 to 14 and issue 2, pages 24 to 27; P. Jung, B. Steiner: "Konzept eines CDMA-Mobilfunksystems mit gemeinsamer Detektion für die dritte Mobilfunkgeneration" [Concept of a CDMA mobile radio system with joint detection for third-generation mobile radios]; **(2):** *Nachrichtentechnik Elektronik [Information Technology Electronics], Berlin 41, 1991, issue 6, pages 223 to 227 and page 234; P.W. Baier, P. Jung, A. Klein: "CDMA - ein günstiges Vielfachzugriffsverfahren für frequenzselektive und zeitvariante Mobilfunkkanäle" [CDMA - a suitable multiple access method for frequency-selective and time-variant mobile radio channels]*; **(3)**: *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences, Vol. E79-A, No. 12, December 1996, pages 1930 to 1937; P.W. Baier, P. Jung: "CDMA Myths and Realities Revisited"*; **(4)**: *IEEE Personal Communications, February 1995, pages 38 to 47; A. Urie, M. Streeton, C. Mourot: "An Advanced TDMA Mobile Access System for UMTS"*; **(5)**: *telekom praxis [Telecommunications practice], 5/1995, pages 9 to 14; P.W. Baier: "Spread-Spectrum-Technik und CDMA - eine ursprünglich militärische Technik erobert den zivilen Bereich" [Spread spectrum technology and CDMA - an originally military technology taking over the civil market]* **(6):** *IEEE Personal Communications, February 1995, pages 48 to 53; P.G. Andermo, L.M. Ewerbring: "A CDMA-Based Radio Access Design for UMTS"*; **(7)**: *ITG Fachberichte [ITG Specialist Reports] 124 (1993), Berlin, Offenbach: VDE*

Verlag ISBN 3-8007-1965-7, pages 67 to 75; Dr. T. Zimmermann, Siemens AG: "Anwendung von CDMA in der Mobilkommunikation" [Use of CDMA in mobile communication]; **(8)**: *telcom report 16, (1993), issue 1, pages 38 to 41; Dr. T. Ketseoglou, Siemens AG and Dr. T. Zimmermann, Siemens AG: "Effizienter Teilnehmerzugriff für die 3. Generation der Mobilkommunikation - Vielfachzugriffsverfahren CDMA macht Luftschnittstelle flexibler" [Efficient subscriber access for third-generation mobile communication - the CDMA multiple access method makes the air interface more flexible];* **(9)**: *Funkschau 6/98: R. Sietmann "Ringen um die UMTS-Schnittstelle" [Fierce competition for the UMTS interface], pages 76 to 81]* WACS or PACS, IS-54, IS-95, PHS, PDC etc. [see IEEE Communications Magazine, January 1995, pages 50 to 57; D.D. Falconer et al: "Time Division Multiple Access Methods for Wireless Personal Communications"]. "Message" is a generic term which covers both the content (information) and the physical representation (signal). Despite a message having the same content - that is to say the same information, different signal forms can occur. Thus, for example, a message relating to an item may be transmitted

(1) in the form of an image,

(2) as a spoken word,

(3) as a written word, <u>or</u>

(4) as an encrypted word or image.

Transmission types (1) … (3) are in this case normally characterized by continuous (analog) signals, while transmission type (4) normally uses discontinuous signals (for example pulses, digital signals).

According to the document Funkschau 6/98: R. Sietmann "Ringen um die UMTS-Schnittstelle" [Fierce competition for the UMTS interface], pages 76 to 81, for example, there are two scenario elements in the UMTS scenario (third-generation mobile radio or IMT-2000). In the first scenario element, the licensed coordinated mobile radio is based on a WCDMA technology (**W**ideband **C**ode **D**ivision **M**ultiple **A**ccess) and, as in the case of GSM, is operated using the FDD mode (**F**requency **D**ivision **D**uplex), while, in the second scenario element, the unlicensed uncoordinated mobile radio is based on a TD-CDMA technology (**T**ime **D**ivision-**C**ode **D**ivision **M**ultiple **A**ccess), and, like DECT, is operated in the TDD mode (**F**requency **D**ivision **D**uplex).

For WCDMA/FDD operation of the Universal Mobile Telecommunications System, the air interface of the telecommunications system, in each case, contains a number of physical channels in the uplink and downlink telecommunications directions, according to the document ETSI STC SMG2 UMTS-L1, Tdoc SMG2 *UMTS-L1 163/98: "UTRA Physical Layer Description FDD Parts" Vers. 0.3, 1998-05-29* of which a first physical channel, the so-called **D**edicated **P**hysical **C**ontrol **Ch**annel DPCCH, and a second physical channel, the so-called **D**edicated **P**hysical **D**ata **Ch**annel DPDCH, are illustrated in Figures 1 and 2 related to their time frame structures.

In the downlink direction (radio link from the base station to the mobile station) in the WCDMA/FDD system from ETSI and ARIB, the dedicated physical control channel (DPCCH) and the Dedicated Physical Data Channel (DPDCH) are time-division multiplexed, while I/Q multiplexing is used in the uplink direction, for which the DPDCH is transmitted in the I-channel and the DPCCH in the Q-channel.

The DPCCH contains N_{pilot} pilot bits for channel estimation, N_{TPC} bits for fast power control and N_{TFI} format bits, which indicate the bit rate, the nature of the service, the nature of the error protection coding, etc. (TFI = Traffic Format Indicator).

Based on a GSM radio scenario with, for example, two radio cells and base stations (**B**ase **T**ransceiver **S**tation), arranged in them, with a first base station BTS1 (transmitter/receiver) "illuminating" a first radio cell FZ1 and a second base station BTS2 (transmitter/receiver) "illuminating" a second radio cell FZ2 omnidirectionally, Figure 3 shows a FDMA/TDMA/CDMA radio scenario, in which the base stations BTS1, BTS2 are connected or can be connected via an air interface, which is designed for the FDMA/TDMA/CDMA radio scenario, to a number of mobile stations MS1...MS5 (transmitter/receiver) located in the radio cells FZ1, FZ2, on appropriate transmission channels TRC ~~by means of~~ via wire-free unidirectional or bidirectional – (uplink direction UL and/or downlink direction DL) - telecommunication. The base stations BTS1, BTS2 are connected in a known manner (see GSM telecommunication system) to a base station

controller BSC (**B**ase **S**tation **C**ontroller) which carries out the frequency management and switching functions in the course of controlling the base stations. For its part, the base station controller BSC is connected via a mobile switching center MSC to the higher-level telecommunications network, for example to the PSTN (Public Switched Telecommunication Network. The mobile switching center MSC is the management center for the illustrated telecommunication system. It carries out all call management functions and, using attached registers (not illustrated), authentication of the telecommunications subscribers and position monitoring in the network.

Figure 4 shows the basic structure of the base station BTS1, BTS2, which are in the form of transmitters/receivers, while Figure 5 shows the basic structure of the mobile stations MT1...MT5, which are likewise in the form of transmitters/receivers. The base stations BTS1, BTS2 transmit and receive radio messages from and to the mobile stations MTS1...MTS5, while the mobile stations MT1...MT5 transmit and receive radio messages from and to the base stations BTS1, BTS2. To this end, the base stations have a transmitting antenna SAN and a receiving antenna EAN, while the mobile stations MT1...MT5 have a joint antenna ANT for transmission and reception, which can be controlled by an antenna switch AU. In the uplink direction (receiving path), the base stations BTS1, BTS2 receive via the receiving antenna EAN, for example, at least one radio message FN with an FDMA/TDMA/CDMA component from at least one of the mobile stations MT1...MT5, while the mobile stations MT1...MT5 receive in

the downlink direction (receiving path), via the common antenna ANT, for example at least one radio message FN with an FDMA/TDMA/CDMA component from at least one base station BTS1, BTS2. The radio message FN in this case ~~comprises~~ includes a broadband-spread carrier signal with information composed of data symbols modulated onto it.

In a radio receiving device FEE (receiver), the received carrier frequency is filtered and is mixed down to an intermediate frequency which, for its part, is then sampled and quantized. After analog/digital conversion, the signal, which has been subject to distortion on the radio path due to multipath propagation, is supplied to an equalizer EQL, which compensates for the majority of the distortion (keyword: synchronization).

A channel estimator KS is then used to attempt to estimate the transmission characteristics of the transmission channel TRC on which the radio message FN has been transmitted. The transmission characteristics of the channel are, in this case, indicated by the channel input response in the time domain. In order to allow the channel impulse response to be estimated, the radio message FN is allocated or assigned at the transmission end (in the present case by the mobile stations MT1...MT5 or the base stations BTS1, BTS2) specific additional information, which is in the form of a training information sequence and is referred to as a midamble.

In a data detector DD following this and which is used jointly for all the received signals, the individual mobile-station-specific signal elements contained

in the common signal are equalized and separated in a known manner. After equalization and separation, a symbol-to-data converter SDW is used to convert the data symbols obtained so far to binary data. After this, a demodulator DMOD is used to obtain the original bit stream from the intermediate frequency before, in a demultiplexer DMUX, the individual timeslots are allocated to the correct logical channels, and thus also to the various mobile stations.

The received bit sequence is decoded channel-by-channel in a channel codec KC. Depending on the channel, the bit information is assigned to the monitoring and signaling timeslots or to a voice timeslot and - ,in the case of the base station (Figure 4) - ,the monitoring and signaling data and the voice data are passed jointly to an interface SS, which is responsible for the signaling and the voice coding/decoding (voice codec) for transmission to the base station controller (BSC)~~,~~. ~~while~~ In the case of the mobile station (Figure 5) - ,the monitoring and signaling data are passed to a control and signaling unit STSE which is responsible for all the signaling and control of the mobile station, and the voice data are passed to a voice codec SPC designed for voice inputting and outputting.

In the voice codec in the interface SS in the base stations BTS1, BTS2, the voice data ~~are [lacuna]~~ is in a predetermined data stream (for example, 64kbps stream in the network direction and 13kbps stream from the network direction).

All the control for the base stations BTS1, BTS2 is carried out in a control unit STE.

In the downlink direction (transmission path), the base stations BTS1, BTS2 transmit via the transmitting antenna SAN, for example, at least one radio message FN with an FDMA/TDMA/CDMA component to at least one of the mobile stations MT1...MT5, while the mobile stations MT1...MT5 transmit in the uplink direction (transmission path) via the common antenna ANT, for example, at least one radio message FN with an FDMA/TDMA/CDMA component to at least one base station BTS1, BTS2.

In Figure 4, the transmission path starts in the base stations BTS1, BTS2 in such a way that monitoring and signaling data received in the channel codec KC from the base station controller BSC via the interface SS, together with voice data are assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

In Figure 5, the transmission path starts in the mobile stations MT1...MT5 in such a manner that voice data received in the channel codec KC from the voice coder SPC and monitoring and signaling data received from the control and signaling unit STSE are assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

The bit sequence obtained in the base stations BTS1, BTS2 and in the mobile stations MT1...MT5 is, in each case, converted in a data-to-symbol converter DSW into data symbols. Following this, the data symbols are ~~in each case~~ spread in a spreading device SPE using a respective subscriber-specific code. In the burst generator BG, ~~comprising~~ including a burst former BZS and a

multiplexer MUX, a training information sequence in the form of a midamble for channel estimation is then ~~in each case~~ added to the spread data symbols in the burst former BZS and, in the multiplexer MUX, the burst information obtained in this way is set to the respective correct timeslot. Finally, the burst obtained is, in each case, radio-frequency modulated and is digital/analog converted in a modulator MOD, before the signal obtained in this way is transmitted as a radio message FN via a radio transmission device FSE (transmitter) at the transmitting antenna SAN or the common antenna ANT.

The problem of multiple reception, that is to say of "delay spreads", when echos are present can be solved in CDMA-based systems, despite the wide bandwidth and the very short chip or bit times in these systems, by the received signals being combined with one another in order to increase the detection probability. The channel characteristics must, of course, be known in order to do this. These channel characteristics are determined using a pilot sequence (see: Figures 1 and 2) which is common to all subscribers and is additionally transmitted without modulation autonomously ~~by means of~~ via a message sequence and with an increased transmission power. The receiver uses its reception to obtain the information as to how many paths are involved in the present reception situation, and what delay times are occurring in the process.

In a RAKE receiver, the signals arriving via the individual paths are detected in separate receivers, the "fingers" of the RAKE receiver, and are added

up, with different weightings to one another, in an addition element after compensation for the delay times and the phase shifts of the echos.

The fingers of the RAKE receiver can be readjusted depending on the change in the transmission channel with the aid of an early and late tracking method (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 6.3) without having to carry out any further time-consuming and resource-intensive channel estimation. To do this, two additional fingers are, in each case, added to each RAKE finger as shown in Figure 6. The two fingers detect the received signal r(t) with the same spread code s(t) as the main finger, the only difference to the main finger being that the received signal in the early finger is advanced by one position, and that in the late finger is delayed by one sample position. This method can be used, in particular, in the case of oversampling. The energies collected from the early and late fingers are compared. The finger position of the main finger is shifted in the direction of the stronger finger after this comparison. This is done only when the energy difference exceeds a specific threshold value. The RAKE receiver is described in more detail in the cited literature (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 14.5).

It can be seen from Figure 6 that the early finger carries out the despreading process for the received signal one delay unit earlier than the actual main finger. The late finger carries out the despreading process precisely one delay unit later than the main finger.

Figure 7 shows the formation of a finger. This ~~comprises~~ includes essentially two multipliers MUL and an accumulation unit AE. Each sampled received value r(t) is multiplied by the spread code s(t) and is weighted with the weighting gw in accordance with a channel estimate, this weighting gw being different for each finger in a RAKE receiver.

The values calculated in this way are now added up in accordance with the spread factor. The result for each finger is a complex signal, which represents a despread symbol. In the early and late fingers, multiplication by the weighting can be omitted, that is to say the weighting is unity. All the signals illustrated in Figures 6 and 7 are complex, and thus ~~comprise~~ include both a real part and an imaginary part. The results obtained from the early and late fingers are evaluated by forming the magnitude, and subsequent comparison of the magnitude. If the magnitudes differ significantly, that is to say they have a minimum difference, which is defined by a value TH, the position of the fingers is varied such that the main finger is located in the position with the greater energy after the change.

This is illustrated in Figure 8. The energy which the early finger calculates, in the stage denoted by P_E, is compared with the energy P_L calculated by the late finger. This is done simply on the basis of evaluation of the energy difference between the two fingers. In the first case, the fingers are not shifted, since the difference between the early and late energy is not particularly large~~,~~ ;~~that is to say~~ i.e., it is significantly less than the threshold value TH to be defined. In the second case, the difference between the early and late fingers is greater

than TH, and the energy of the late finger is greater than the energy of the early finger. In consequence, the main finger is shifted by one delay stage to the rear. In the third case, the difference between the early and late fingers is likewise greater than TH and, this time, the energy of the early finger is greater than the energy of the late finger. In consequence, the main finger is shifted by one delay stage forward.

The problem described in the following text can occur when using early and late fingers in the rake receivers:

If, as shown in Figure 9, the received data ~~are~~ is buffer-stored in an RAM memory SP, in order then to be passed on by appropriate memory accesses via a multiplexer MUX to the RAKE receiver, then three memory accesses must be carried out per RAKE finger. One access is, in each case, required for the main, the early and the late finger. If, for example, the data ~~are~~ is written to the memory using a 4 MHz sampling frequency, then that memory must be readable at 96 MHz if there are eight RAKE fingers. This ratio changes in the case of oversampling since, then, the data ~~are~~ is written to the memory at a higher speed, corresponding to the oversampling rate.

Figure 9 shows a conventional circuit. The three RAKE fingers access the RAM memory SP independently of one another via the multiplexer MUX. The scrambling is reversed (descrambling), and path weighting is carried out in a known manner ~~by means of~~ via a number of multipliers MUL in the RAKE receiver.

~~The~~ An object on which the present invention is based is to specify a method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/ receivers, in particular in third-generation mobile radio systems, in which the number of memory accesses is less than with the previously known methods.

SUMMARY OF THE INVENTION

Accordingly, ~~to the patent claim, this object is achieved in that~~ the present invention is directed to a method wherein data which ~~are~~ is received in the RAKE receiver and ~~are~~ is read by an early finger in the early-late tracking ~~are~~ is buffer-stored and ~~are~~ is passed on one read cycle later to a late finger for reading by the same in the early-late tracking.

~~The~~ An idea on which the present invention is based is to make use of a characteristic which results from the ratio of the early and late data to one another. The data which ~~are~~ is read by an early finger ~~are~~ is read one read cycle later by the corresponding late finger. It is thus sufficient to buffer-store data read by the early finger in a memory and to pass such data on appropriately to the late finger which then need no longer itself directly access the memory. If no oversampling is used, then it is even possible to replace all three memory accesses by just one. If the early and the late finger share one memory access, the total number of memory accesses is reduced by 1/3. The use of slower and, thus, more cost-effective memory modules is hence possible.

~~An exemplary embodiment of the invention will be explained with reference to Figure 10.~~

Additional features and advantages of the present invention are described in, and will be apparent from, the Detailed Description of the Preferred Embodiments and the Drawings.

DESCRIPTION OF THE DRAWINGS

Figures 1 and 2 show, for the WCDMA/FDD operation of the universal mobile telecommunication system, the Dedicated Physical Control Channel and the Dedicated Physical Data Channel of the air interface of a telecommunication system with respect to their framed structures;

Figure 3 shows, on the basis of the GSM radio scenario, first and second base transceiver stations;

Figure 4 shows the basic configuration of the base transceiver station constructed as a transceiver;

Figure 5 shows the basic configuration of the mobile station constructed as a transceiver;

Figure 6 shows the fingers of the RAKE receiver being readjusted wherein two additional fingers are added to each RAKE finger;

Figure 7 shows the formation of a finger including two multipliers and an accumulation unit;

Figure 8 illustrates the evaluation of the energy difference between the early and late fingers;

Figure 9 shows a conventional circuit wherein three RAKE fingers access the RAM memory independently of one another via a multiplexor; and

Figure 10 shows a modified version of the circuit shown in Figure 9 wherein one memory access can be saved in the case of memory accesses in a RAKE receiver.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Based on Figure 9, Figure 10 shows how one memory access can be saved in the case of memory accesses in a RAKE receiver.

Figure 10 shows a circuit modified from that in Figure 9. Two of the three RAKE fingers, the main finger and the early finger, once again access the RAM memory SP via the multiplexer MUX independently of one another. Once again, the scrambling is reversed (descrambling) and a path weighting is carried out in a known manner using a number of multipliers MUL in the RAKE receiver. In the case of access by the early finger for the early-late tracking, the data read from the RAM memory SP ~~are~~ is buffer-stored in a buffer store (register) ZSP, and ~~are~~ is passed on one read cycle later to the late finger for reading by the same in the early-late tracking.

To assist understanding of the memory access process shown in Figure 10, this process will be described for the following access scenario, which relates to one finger. In the example, the oversampling rate is chosen to have a value “2”, that is to say two samples per chip are stored in the memory SP.

The received signal is stored in the RAM memory SP at a sampling rate $T_c/2$, T_c is the time duration of a chip.

The read address is calculated from the path delay. Only data in the T_c frame are required for despreading the signal.

Example: Delay = 7* T_c, ~~this means that~~ refers to the signal ~~is~~ being delayed by 7 chips, and the first correct value is that in the 7th chip position.

Since two samples are stored per chip, ~~this means that~~ the first sample must be read at the address "14 (14/2 = 7)".

The received signal is read starting from the address "14". The address counter then counts onwards in steps of 2. Addresses "14, 16, 18, 20, 22, 24 etc." are thus read. This applies to the main finger.

The early and late fingers require the signal delayed by half a chip and the signal that arrived half a chip earlier, respectively.

~~This means that~~ Thus, the addresses "13, 15, 17, 19, 21 etc." are read for the early finger, while the addresses "15, 17, 19, 21, 23 etc." are read for the late finger.

This can be done quite easily since the values in the $T_c/2$ frame are stored in the RAM memory SP so that the early address can be calculated from the main address minus 1, and the late address can be calculated from the main address plus 1.

The addresses "13, 14 and 15" therefore need to be read from the memory SP in the first step. The addresses "15, 16 and 17" are read in the second step, etc.

If the procedure used in the circuit shown in Figure 9 is used, then 3 memory accesses are required per calculation step~~. This means~~; resulting in an access speed of 12 MHz for a 4 MHz signal. If the memory is now read simultaneously by 8 fingers, that is to say 8 early fingers, 8 late fingers and 8 main fingers, then ~~this means that~~ access is required at 12*8 MHz = 96 MHz.

However, with this configuration, the memory location "15" is read in the second step, although it has already been used in the first step. One memory access per processing step is thus sufficient for the early and late fingers. The value for the late finger is obtained by delaying the value for the early finger by one chip. Thus, if the early finger reads the value "15", the output of the delay element for the late finger is first fed with the value "17". However, this results in the correct sequence for the various fingers.

The number of memory accesses can, thus, be reduced by 1/3 since the early and late fingers share one memory access. Slower and ~~thus~~ more cost-effective memory modules can ~~thus~~ then be used~~,~~ which, in turn, results in reduced power consumption.

Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

ABSTRACT OF THE DISCLOSURE

~~A method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-generation mobile radio systems.~~

In order to control memory accesses in RAKE receivers having early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-generation mobile radio systems, such that the number of memory accesses is less than with previous known methods, data which ~~are~~ is received in the RAKE receiver and ~~are~~ is read by an early finger in the early-late tracking ~~are~~ is buffer-stored and ~~are~~ is passed on one read cycle later to a late finger for reading by the same in the early-late tracking.

~~FIGURE 10~~

7/PRTS

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JC18 Rec'd PCT/PTO 27 APR 2001

GR 98 P 2965

Description

Method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-generation mobile radio systems

Telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers are specific message systems with a message transmission path between a message source and a message sink, in which, for example, base stations and mobile parts are used as transmitters and receivers for message processing and transmission, and in which

1) the message processing and message transmission can take place in one preferred transmission direction (simplex operation) or in both transmission directions (duplex operation),

2) the message processing is preferably digital,

3) the messages are transmitted via the long-distance transmission path without wires based on various message transmission methods FDMA (**F**requency **D**ivision **M**ultiple **A**ccess), TDMA (**T**ime **D**ivision **M**ultiple **A**ccess) and/or CDMA (**C**ode **D**ivision **M**ultiple **A**ccess) - for example in accordance with radio standards such as DECT [**D**igital **E**nhanced (previously: **E**uropean) **C**ordless **T**elecommunication; see *Nachrichtentechnik Elektronik* [Information Technology Electronics] *42 (1992) Jan./Feb. No. 1, Berlin, DE; U. Pilger "Struktur des DECT-Standards" [Structure of the DECT Standard], pages 23 to 29* **in conjunction with** ETSI Publication *ETS 300175-1…9, October 1992* and the DECT Publication from the *DECT Forum, February 1997, pages 1 to 16],*

GSM [**G**roupe **S**péciale **M**obile or **G**lobal **S**ystem for **M**obile Communication; see *Informatik Spectrum* [Information Technology Spectrum] *14 (1991) June No. 3, Berlin, DE; A. Mann: "Der GSM-Standard - Grundlage für digitale europäische Mobilfunknetze" [The GSM Standard - Basis of digital European mobile networks], pages 137 to 152* **in conjunction with** the publication *telekom praxis 4/1993, P. Smolka "GSM-Funkschnittstelle - Elemente und Funktionen" [Telecommunications in practice] [GSM radiointerface - Elements and functions]*

Pages 17 to 24] UMTS [**U**niversal **M**obile **T**elecommunication **S**ystem; see **(1):** *Nachrichtentechnik Elektronik [Information Technology Electronics], Berlin 45, 1995, issue 1, pages 10 to 14 and issue 2, pages 24 to 27; P. Jung, B. Steiner: "Konzept eines CDMA-Mobilfunksystems mit gemeinsamer Detektion für die dritte Mobilfunkgeneration" [Concept of a CDMA mobile radio system with joint detection for third-generation mobile radios];* **(2):** *Nachrichtentechnik Elektronik [Information Technology Electronics], Berlin 41, 1991, issue 6, pages 223 to 227 and page 234; P.W. Baier, P. Jung, A. Klein: "CDMA - ein günstiges Vielfachzugriffsverfahren für frequenzselektive und zeitvariante Mobilfunkkanäle" [CDMA - a suitable multiple access method for frequency-selective and time-variant mobile radio channels];* **(3):** *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences, Vol. E79-A, No. 12, December 1996, pages 1930 to 1937; P.W. Baier, P. Jung: "CDMA Myths and Realities Revisited";* **(4):** *IEEE Personal Communications, February 1995, pages 38 to 47; A. Urie, M. Streeton, C. Mourot: "An Advanced TDMA Mobile Access System for UMTS";* **(5):** *telekom praxis [Telecommunications practice], 5/1995, pages 9 to 14; P.W. Baier: "Spread-Spectrum-Technik und CDMA - eine ursprünglich militärische Technik erobert den zivilen Bereich" [Spread spectrum technology and CDMA - an originally military technology taking over the civil market]* **(6):** *IEEE Personal Communications, February 1995, pages 48 to 53; P.G. Andermo, L.M. Ewerbring: "A CDMA-Based Radio Access Design for UMTS";* **(7):** *ITG Fachberichte [ITG Specialist Reports] 124 (1993), Berlin, Offenbach: VDE Verlag ISBN 3-8007-1965-7, pages 67 to 75; Dr. T. Zimmermann, Siemens AG: "Anwendung von CDMA in*

der Mobilkommunikation" [Use of CDMA in mobile communication]; **(8)**: *telcom report 16, (1993), issue 1, pages 38 to 41; Dr. T. Ketseoglou, Siemens AG and Dr. T. Zimmermann, Siemens AG: "Effizienter Teilnehmerzugriff für die 3. Generation der Mobilkommunikation – Vielfachzugriffsverfahren CDMA macht Luftschnittstelle flexibler" [Efficient subscriber access for third-generation mobile communication – the CDMA multiple access method makes the air interface more flexible];* **(9)**: *Funkschau 6/98: R. Sietmann "Ringen um die UMTS-Schnittstelle" [Fierce competition for the UMTS interface], pages 76 to 81]* WACS or PACS, IS-54, IS-95, PHS, PDC etc. [see IEEE Communications Magazine, January 1995, pages 50 to 57; D.D. Falconer et al: "Time Division Multiple Access Methods for Wireless Personal Communications"].

"Message" is a generic term which covers both the content (information) and the physical representation (signal). Despite a message having the same content - that is to say the same information, different signal forms can occur. Thus, for example, a message relating to an item may be transmitted

(1) in the form of an image,
(2) as a spoken word,
(3) as a written word,
(4) as an encrypted word or image.

Transmission types (1) … (3) are in this case normally characterized by continuous (analog) signals, while transmission type (4) normally uses discontinuous signals (for example pulses, digital signals).

According to the document *Funkschau 6/98: R. Sietmann "Ringen um die UMTS-Schnittstelle" [Fierce competition for the UMTS interface], pages 76 to 81, for example, there are two scenario elements in the UMTS scenario (third-generation mobile radio or IMT-2000)*. In the first scenario element, the licensed coordinated mobile radio is based on a WCDMA technology (**W**ideband **C**ode **D**ivision **M**ultiple **A**ccess) and, as in the case of GSM, is operated using the FDD mode (**F**requency **D**ivision **D**uplex), while, in the second scenario element, the unlicensed uncoordinated mobile radio is based on a TD-CDMA technology (**T**ime **D**ivision-**C**ode **D**ivision **M**ultiple **A**ccess), and, like DECT, is operated in the TDD mode (**F**requency **D**ivision **D**uplex).

For WCDMA/FDD operation of the Universal Mobile Telecommunications System, the air interface of the telecommunications system in each case contains a number of physical channels in the uplink and downlink telecommunications directions, according to the document *ETSI STC SMG2 UMTS-L1, Tdoc SMG2*

UMTS-L1 163/98: "UTRA Physical Layer Description FDD Parts" Vers. 0.3, 1998-05-29 of which a first physical channel, the so-called **D**edicated **P**hysical **C**ontrol **Ch**annel DPCCH, and a second physical

channel, the so-called **D**edicated **P**hysical **D**ata **Ch**annel DPDCH, are illustrated in Figures 1 and 2 related to their time frame structures.

In the downlink direction (radio link from the base station to the mobile station) in the WCDMA/FDD system from ETSI and ARIB, the dedicated physical control channel (DPCCH) and the Dedicated Physical Data Channel (DPDCH) are time-division multiplexed, while I/Q multiplexing is used in the uplink direction, for which the DPDCH is transmitted in the I-channel and the DPCCH in the Q-channel.

The DPCCH contains N_{pilot} pilot bits for channel estimation, N_{TPC} bits for fast power control and N_{TFI} format bits, which indicate the bit rate, the nature of the service, the nature of the error protection coding, etc. (TFI = Traffic Format Indicator).

Based on a GSM radio scenario with, for example, two radio cells and base stations (**B**ase **T**ransceiver **S**tation), arranged in them, with a first base station BTS1 (transmitter/receiver) "illuminating" a first radio cell FZ1 and a second base station BTS2 (transmitter/receiver) "illuminating" a second radio cell FZ2 omnidirectionally, Figure 3 shows a FDMA/TDMA/CDMA radio scenario, in which the base stations BTS1, BTS2 are connected or can be connected via an air interface, which is designed for the FDMA/TDMA/CDMA radio scenario, to a number of mobile stations MS1…MS5 (transmitter/receiver) located in the radio cells FZ1, FZ2, on appropriate transmission channels TRC by means of wire-free unidirectional or bidirectional - uplink direction UL and/or downlink direction DL - telecommunication. The base stations BTS1, BTS2 are connected in a known manner (see GSM telecommunication system) to a base station controller BSC (**B**ase **S**tation **C**ontroller) which carries out the frequency management and switching functions in

the course of controlling the base stations. For its part, the base station controller BSC is connected via a mobile switching center MSC to the higher-level telecommunications network, for example to the

PSTN (Public Switched Telecommunication Network. The mobile switching center MSC is the management center for the illustrated telecommunication system. It carries out all call management functions and, using attached registers (not illustrated), authentication of the telecommunications subscribers and position monitoring in the network.

Figure 4 shows the basic structure of the base station BTS1, BTS2, which are in the form of transmitters/receivers, while Figure 5 shows the basic structure of the mobile stations MT1...MT5, which are likewise in the form of transmitters/receivers. The base stations BTS1, BTS2 transmit and receive radio messages from and to the mobile stations MTS1...MTS5, while the mobile stations MT1...MT5 transmit and receive radio messages from and to the base stations BTS1, BTS2. To this end, the base stations have a transmitting antenna SAN and a receiving antenna EAN, while the mobile stations MT1...MT5 have a joint antenna ANT for transmission and reception, which can be controlled by an antenna switch AU. In the uplink direction (receiving path), the base stations BTS1, BTS2 receive via the receiving antenna EAN, for example, at least one radio message FN with an FDMA/TDMA/CDMA component from at least one of the mobile stations MT1...MT5, while the mobile stations MT1...MT5 receive in the downlink direction (receiving path), via the common antenna ANT, for example at least one radio message FN with an FDMA/TDMA/CDMA component from at least one base station BTS1, BTS2. The radio message FN in this case comprises a broadband-spread carrier signal with information composed of data symbols modulated onto it.

In a radio receiving device FEE (receiver), the received carrier frequency is filtered and is mixed down to an intermediate frequency which, for its part, is then sampled and quantized. After

analog/digital conversion, the signal, which has been subject to distortion on the radio path due to multipath propagation, is supplied to an equalizer EQL, which

compensates for the majority of the distortion (keyword: synchronization).

A channel estimator KS is then used to attempt to estimate the transmission characteristics of the transmission channel TRC on which the radio message FN has been transmitted. The transmission characteristics of the channel are in this case indicated by the channel input response in the time domain. In order to allow the channel impulse response to be estimated, the radio message FN is allocated or assigned at the transmission end (in the present case by the mobile stations MT1…MT5 or the base stations BTS1, BTS2) specific additional information, which is in the form of a training information sequence and is referred to as a midamble.

In a data detector DD following this and which is used jointly for all the received signals, the individual mobile-station-specific signal elements contained in the common signal are equalized and separated in a known manner. After equalization and separation, a symbol-to-data converter SDW is used to convert the data symbols obtained so far to binary data. After this, a demodulator DMOD is used to obtain the original bit stream from the intermediate frequency before, in a demultiplexer DMUX, the individual timeslots are allocated to the correct logical channels, and thus also to the various mobile stations.

The received bit sequence is decoded channel-by-channel in a channel codec KC. Depending on the channel, the bit information is assigned to the monitoring and signaling timeslots or to a voice timeslot and - in the case of the base station (Figure 4) - the monitoring and signaling data and the voice data are passed jointly to an interface SS, which is responsible for the signaling and the voice coding/decoding (voice codec) for transmission to the

base station controller (BSC), while - in the case of the mobile station (Figure 5) - the monitoring and signaling data are passed to a

control and signaling unit STSE which is responsible for all the signaling and control of the mobile station, and the voice data are passed to a voice codec SPC designed for voice inputting and outputting.

In the voice codec in the interface SS in the base stations BTS1, BTS2, the voice data are [lacuna] in a predetermined data stream (for example 64kbps stream in the network direction and 13kbps stream from the network direction).

All the control for the base stations BTS1, BTS2 is carried out in a control unit STE.

In the downlink direction (transmission path), the base stations BTS1, BTS2 transmit via the transmitting antenna SAN, for example, at least one radio message FN with an FDMA/TDMA/CDMA component to at least one of the mobile stations MT1…MT5, while the mobile stations MT1…MT5 transmit in the uplink direction (transmission path) via the common antenna ANT, for example, at least one radio message FN with an FDMA/TDMA/CDMA component to at least one base station BTS1, BTS2.

In Figure 4, the transmission path starts in the base stations BTS1, BTS2 in such a way that monitoring and signaling data received in the channel codec KC from the base station controller BSC via the interface SS, together with voice data are assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

In Figure 5, the transmission path starts in the mobile stations MT1…MT5 in such a manner that voice data received in the channel codec KC from the voice coder SPC and monitoring and signaling data received from the control and signaling unit STSE are

assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

The bit sequence obtained in the base stations BTS1, BTS2 and in the mobile stations MT1…MT5 is in each case converted in a data-to-symbol converter DSW into data symbols. Following this, the data symbols are in each case spread in a spreading device SPE using a respective subscriber-specific code. In the burst generator BG, comprising a burst former BZS and a multiplexer MUX, a training information sequence in the form of a midamble for channel estimation is then in each case added to the spread data symbols in the burst former BZS and, in the multiplexer MUX, the burst information obtained in this way is set to the respective correct timeslot. Finally, the burst obtained is in each case radio-frequency modulated and is digital/analog converted in a modulator MOD, before the signal obtained in this way is transmitted as a radio message FN via a radio transmission device FSE (transmitter) at the transmitting antenna SAN or the common antenna ANT.

The problem of multiple reception, that is to say of "delay spreads", when echos are present can be solved in CDMA-based systems, despite the wide bandwidth and the very short chip or bit times in these systems, by the received signals being combined with one another in order to increase the detection probability. The channel characteristics must, of course, be known in order to do this. These channel characteristics are determined using a pilot sequence (see: Figures 1 and 2) which is common to all subscribers and is additionally transmitted without modulation autonomously by means of a message sequence and with an increased transmission power. The receiver uses its reception to obtain the information as to how many paths are involved in the present reception situation, and what delay times are occurring in the process.

In a RAKE receiver, the signals arriving via

the individual paths are detected in separate receivers, the "fingers" of the RAKE receiver, and are added up, with

different weightings to one another, in an addition element after compensation for the delay times and the phase shifts of the echos.

The fingers of the RAKE receiver can be readjusted depending on the change in the transmission channel with the aid of an early and late tracking method (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 6.3) without having to carry out any further time-consuming and resource-intensive channel estimation. To do this, two additional fingers are in each case added to each RAKE finger as shown in Figure 6. The two fingers detect the received signal r(t) with the same spread code s(t) as the main finger, the only difference to the main finger being that the received signal in the early finger is advanced by one position, and that in the late finger is delayed by one sample position. This method can be used in particular in the case of oversampling. The energies collected from the early and late fingers are compared. The finger position of the main finger is shifted in the direction of the stronger finger after this comparison. This is done only when the energy difference exceeds a specific threshold value. The RAKE receiver is described in more detail in the cited literature (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 14.5).

It can be seen from Figure 6 that the early finger carries out the despreading process for the received signal one delay unit earlier than the actual main finger. The late finger carries out the despreading process precisely one delay unit later than the main finger.

Figure 7 shows the formation of a finger. This comprises essentially two multipliers MUL and an

accumulation unit AE. Each sampled received value $r(t)$ is multiplied by the spread code $s(t)$ and is weighted

with the weighting gw in accordance with a channel estimate, this weighting gw being different for each finger in a RAKE receiver.

The values calculated in this way are now added up in accordance with the spread factor. The result for each finger is a complex signal, which represents a despread symbol. In the early and late fingers, multiplication by the weighting can be omitted, that is to say the weighting is unity. All the signals illustrated in Figures 6 and 7 are complex, and thus comprise a real part and an imaginary part.

The results obtained from the early and late fingers are evaluated by forming the magnitude, and subsequent comparison of the magnitude. If the magnitudes differ significantly, that is to say they have a minimum difference, which is defined by a value TH, the position of the fingers is varied such that the main finger is located in the position with the greater energy after the change.

This is illustrated in Figure 8. The energy which the early finger calculates, in the stage denoted by P_E, is compared with the energy P_L calculated by the late finger. This is done simply on the basis of evaluation of the energy difference between the two fingers. In the first case, the fingers are not shifted, since the difference between the early and late energy is not particularly large, that is to say it is significantly less than the threshold value TH to be defined. In the second case, the difference between the early and late fingers is greater than TH, and the energy of the late finger is greater than the energy of the early finger. In consequence, the main finger is shifted by one delay stage to the rear. In the third case, the difference between the early and late fingers is likewise greater than TH and, this time, the energy of the

early finger is greater than the energy of the late finger. In consequence, the main finger is shifted by one delay stage forward.

The problem described in the following text can occur when using early and late fingers in the rake receivers:

If, as shown in Figure 9, the received data are buffer-stored in an RAM memory SP, in order then to be passed on by appropriate memory accesses via a multiplexer MUX to the RAKE receiver, then three memory accesses must be carried out per RAKE finger. One access is in each case required for the main, the early and the late finger. If, for example, the data are written to the memory using a 4 MHz sampling frequency, then that memory must be readable at 96 MHz if there are eight RAKE fingers. This ratio changes in the case of oversampling since, then, the data are written to the memory at a higher speed, corresponding to the oversampling rate.

Figure 9 shows a conventional circuit. The three RAKE fingers access the RAM memory SP independently of one another via the multiplexer MUX. The scrambling is reversed (descrambling), and path weighting is carried out in a known manner by means of a number of multipliers MUL in the RAKE receiver.

The object on which the invention is based is to specify a method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-generation mobile radio systems, in which the number of memory accesses is less than with the previously known methods.

According to the patent claim, this object is achieved in that data which are received in the RAKE receiver and are read by an early finger in the early-late tracking

are buffer-stored and are passed on one read cycle later to a late finger for reading by the same in the early-late tracking.

The idea on which the invention is based is to make use of a characteristic which results from the ratio of the early and late data to one another. The data which are read by an early finger are read one read cycle later by the corresponding late finger. It is thus sufficient to buffer-store data read by the early finger in a memory and to pass such data on appropriately to the late finger which then need no longer itself directly access the memory. If no oversampling is used, then it is even possible to replace all three memory accesses by just one. If the early and the late finger share one memory access, the total number of memory accesses is reduced by 1/3. The use of slower and thus more cost-effective memory modules is hence possible.

An exemplary embodiment of the invention will be explained with reference to Figure 10.

Based on Figure 9, Figure 10 shows how one memory access can be saved in the case of memory accesses in a RAKE receiver.

Figure 10 shows a circuit modified from that in Figure 9. Two of the three RAKE fingers, the main finger and the early finger, once again access the RAM memory SP via the multiplexer MUX independently of one another. Once again, the scrambling is reversed (descrambling) and a path weighting is carried out in a known manner using a number of multipliers MUL in the RAKE receiver. In the case of access by the early finger for the early-late tracking, the data read from the RAM memory SP are buffer-stored in a buffer store (register) ZSP, and

are passed on one read cycle later to the late finger for reading by the same in the early-late tracking.

To assist understanding of the memory access process shown in Figure 10, this process will be described for the following access scenario, which relates to one finger. In the example, the oversampling rate is chosen to have a value "2", that is to say two samples per chip are stored in the memory SP.

The received signal is stored in the RAM memory SP at a sampling rate $T_c/2$, T_c is the time duration of a chip.

The read address is calculated from the path delay. Only data in the T_c frame are required for despreading the signal.

<u>Example</u>: Delay = 7* T_c, this means that the signal is delayed by 7 chips, and the first correct value is that in the 7th chip position.

Since two samples are stored per chip, this means that the first sample must be read at the address "14 (14/2 = 7)".

The received signal is read starting from the address "14". The address counter then counts onwards in steps of 2. Addresses "14, 16, 18, 20, 22, 24 etc." are thus read. This applies to the main finger.

The early and late fingers require the signal delayed by half a chip and the signal that arrived half a chip earlier, respectively.

This means that the addresses "13, 15, 17, 19, 21 etc." are read for the early finger, while the addresses "15, 17, 19, 21, 23 etc." are read for the late finger.

This can be done quite easily since the values in the $T_c/2$ frame are stored in the RAM memory SP so that the early address can be calculated from the main address minus 1, and the late address can be calculated from the main address plus 1.

The addresses "13, 14 and 15" therefore need to be read from the memory SP in the first step. The addresses "15, 16 and 17" are read in the second step, etc.

If the procedure used in the circuit shown in Figure 9 is used, then 3 memory accesses are required per calculation step. This means an access speed of 12 MHz for a 4 MHz signal. If the memory is now read simultaneously by 8 fingers, that is to say 8 early fingers, 8 late fingers and 8 main fingers, then this means that access is required at 12*8 MHz = 96 MHz.

However, with this configuration, the memory location "15" is read in the second step, although it has already been used in the first step. One memory access per processing step is thus sufficient for the early and late fingers. The value for the late finger is obtained by delaying the value for the early finger by one chip. Thus, if the early finger reads the value "15", the output of the delay element for the late finger is first fed with the value "17". However, this results in the correct sequence for the various fingers.

The number of memory accesses can thus be reduced by 1/3 since the early and late fingers share one memory access. Slower and thus more cost-effective memory modules can thus be used, which in turn results in reduced power consumption.

Patent Claim

A method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-generation mobile radio systems, having the following feature:

data which are received in the RAKE receiver and are read by an early finger in the early-late tracking are buffer-stored and are passed on one read cycle later to a late finger for reading by the same in the early-late tracking.

09/830624

FIG 1

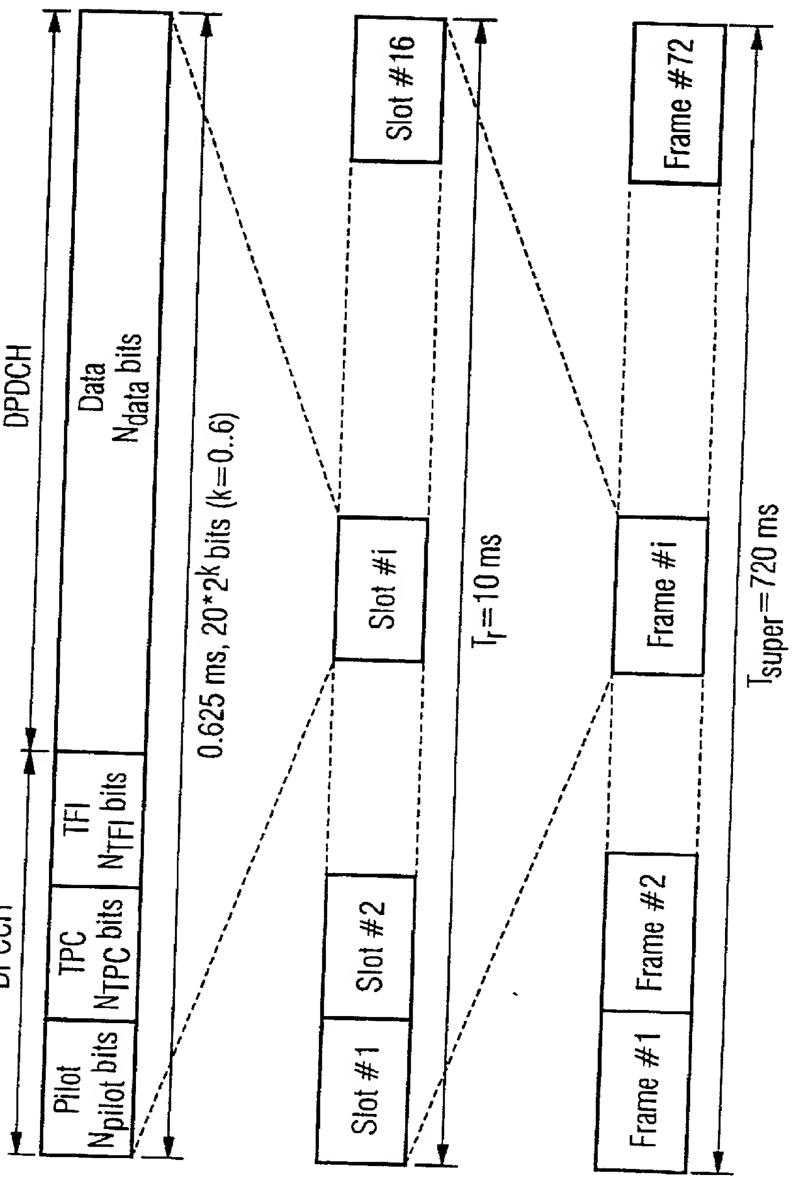


FIG 2

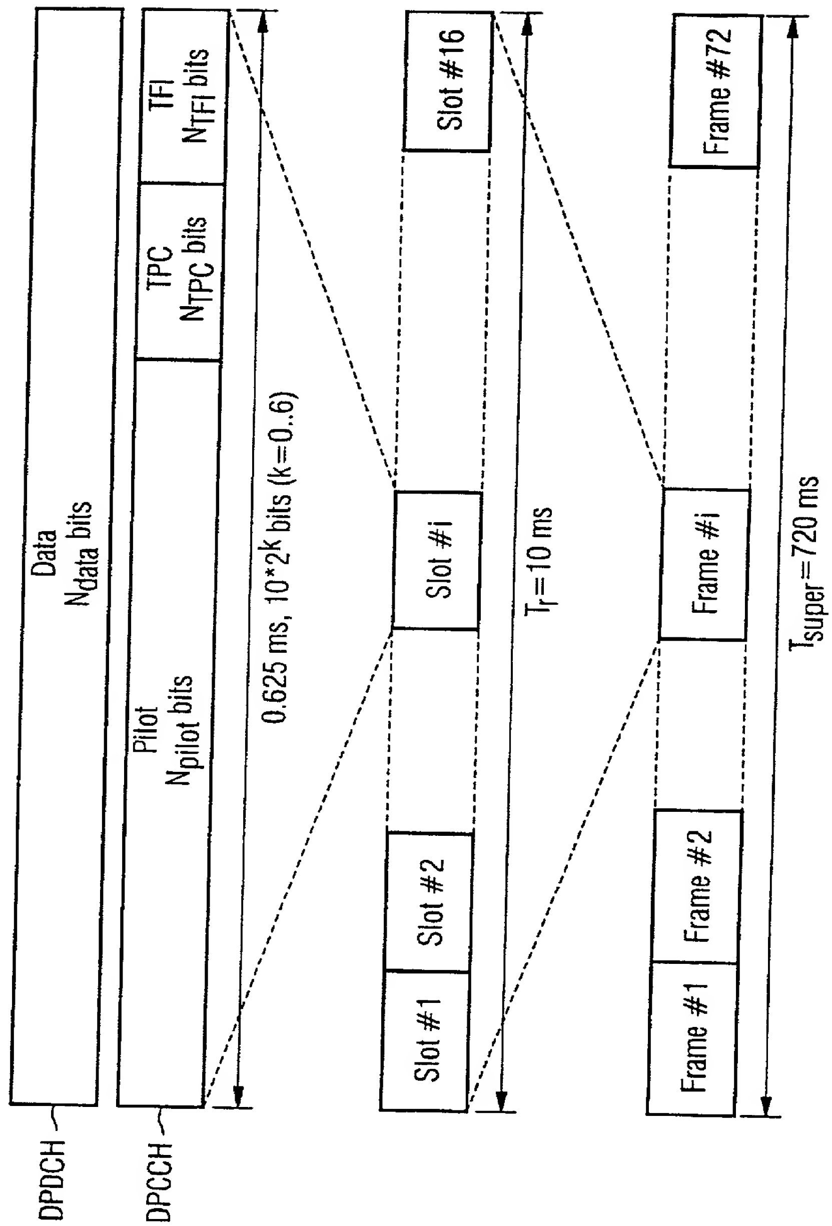

Data
N_{data} bits
Pilot
N_{pilot} bits
TPC
N_{TPC} bits
TFI
N_{TFI} bits
DPDCH
DPCCH
0.625 ms, $10*2^k$ bits (k=0..6)
Slot #1
Slot #2
Slot #i
Slot #16
T_f=10 ms
Frame #1
Frame #2
Frame #i
Frame #72
T_{super}=720 ms

FIG 3

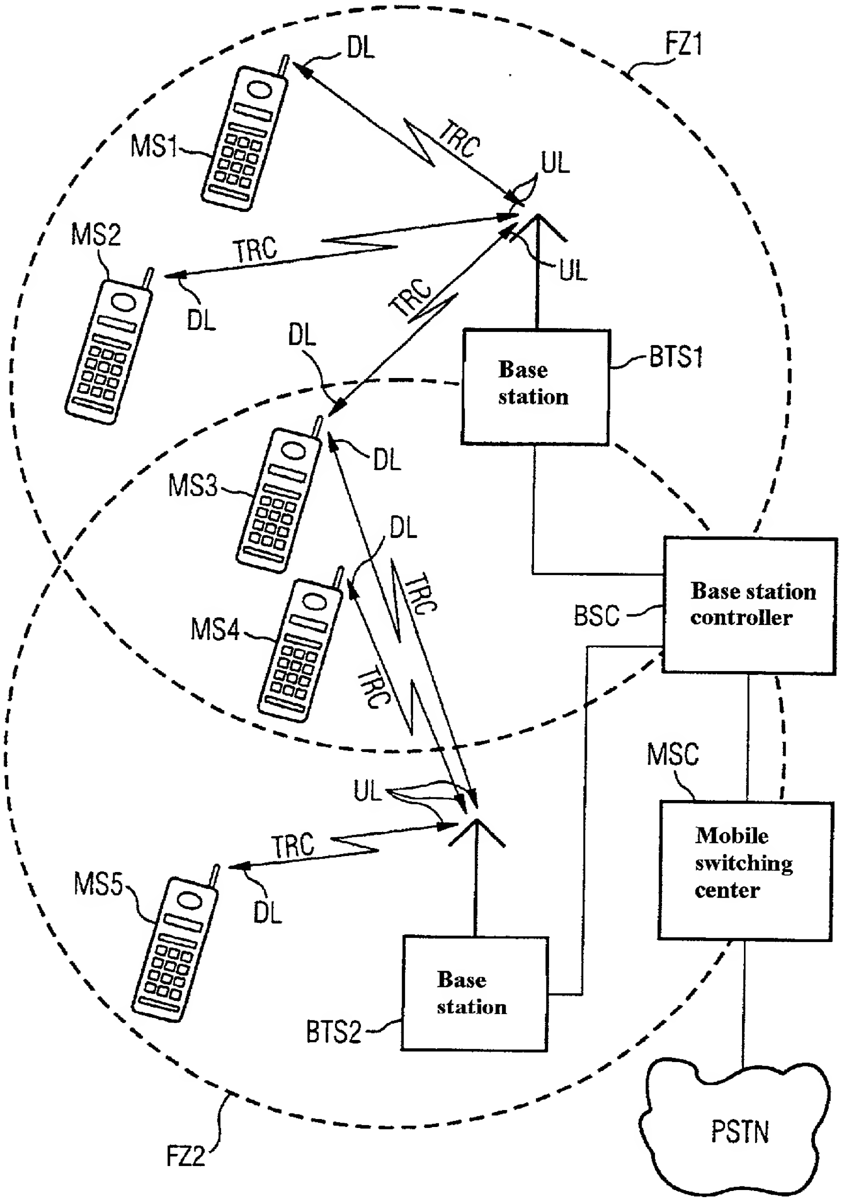
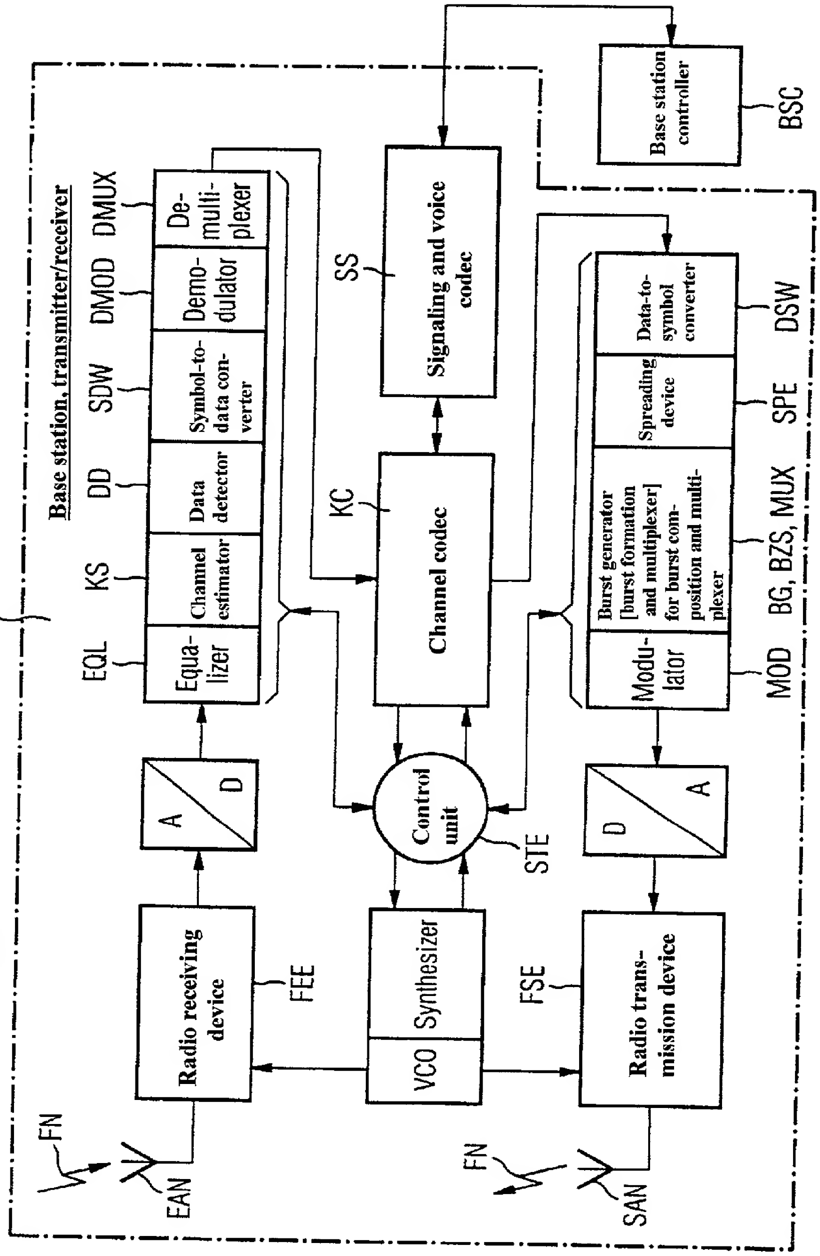

DL
FZ1
TRC
MS1
UL
MS2
TRC
UL
DL
TRC
DL
Base station
BTS1
DL
MS3
DL
TRC
MS4
BSC
Base station controller
TRC
MSC
UL
TRC
Mobile switching center
MS5
DL
Base station
BTS2
PSTN
FZ2

FIG 4



BTS1, BTS2
Base station, transmitter/receiver
Base station controller
BSC
Signaling and voice codec
SS
Channel codec
KC
Control unit
STE
Equa-lizer
EQL
Channel estimator
KS
Data detector
DD
Symbol-to-data con-verter
SDW
Demo-dulator
DMOD
De-multi-plexer
DMUX
A
D
Radio receiving device
FEE
Synthesizer
VCO
FN
EAN
Modu-lator
MOD
Burst generator [burst formation and multiplexer] for burst com-position and multi-plexer
BG, BZS, MUX
Spreading device
SPE
Data-to-symbol converter
DSW
D
A
Radio trans-mission device
FSE
FN
SAN

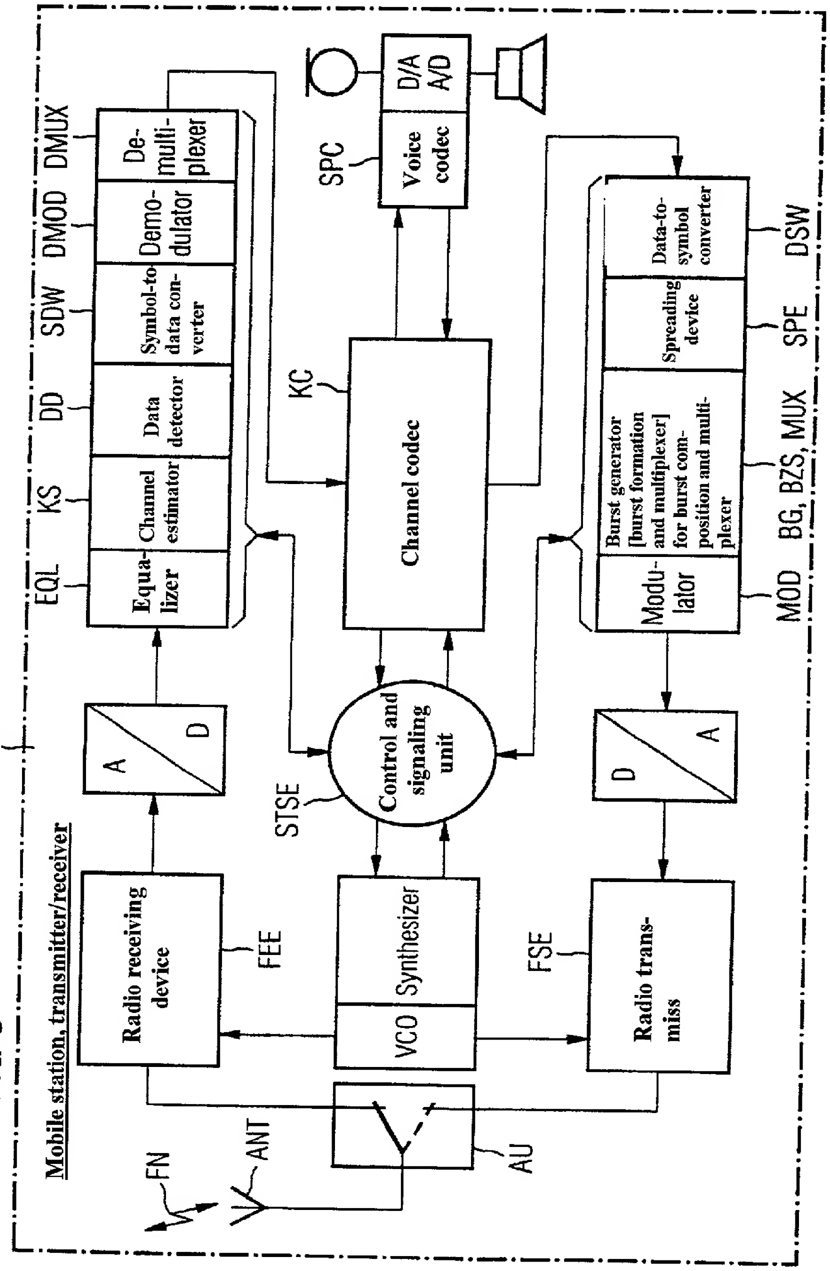

Mobile station, transmitter/receiver
MS1 ... MS5
Radio receiving device
FEE
A
D
Equa-lizer
EQL
Channel estimator
KS
Data detector
DD
Symbol-to-data con-verter
SDW
Demo-dulator
DMOD
De-multi-plexer
DMUX
Voice codec
SPC
D/A
A/D
Channel codec
KC
Control and signaling unit
STSE
VCO
Synthesizer
Radio trans-miss
FSE
D
A
Modu-lator
MOD
Burst generator [burst formation and multiplexer] for burst com-position and multi-plexer
BG, BZS, MUX
Spreading device
SPE
Data-to-symbol converter
DSW
FN
ANT
AU

FIG 5

FIG 6

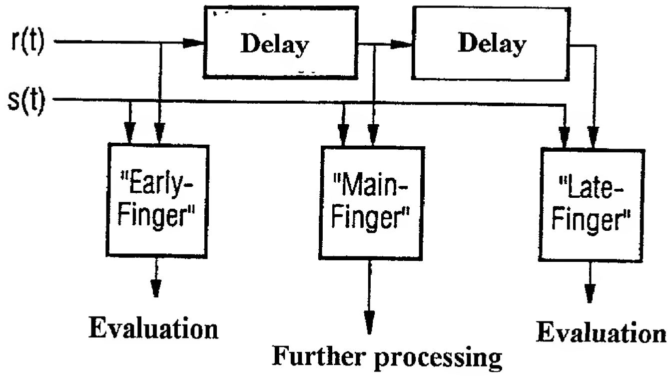


FIG 7

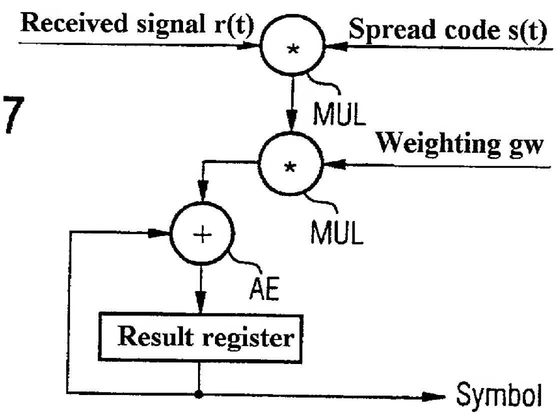


FIG 8

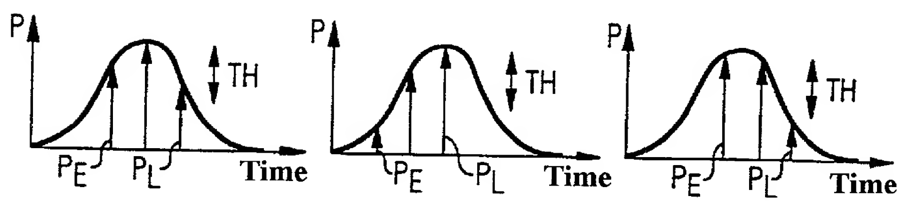


FIG 9

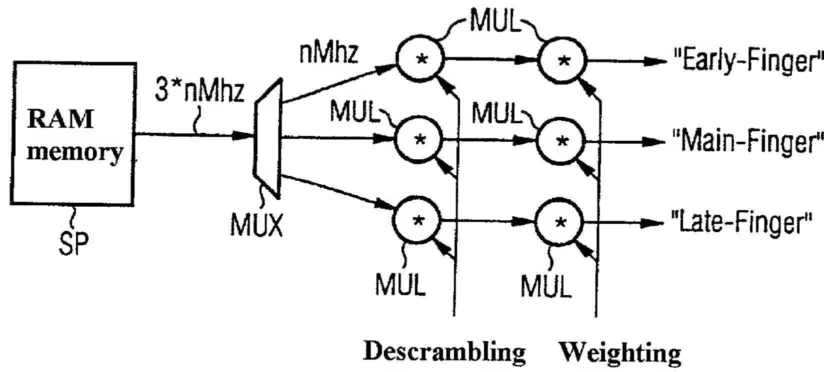
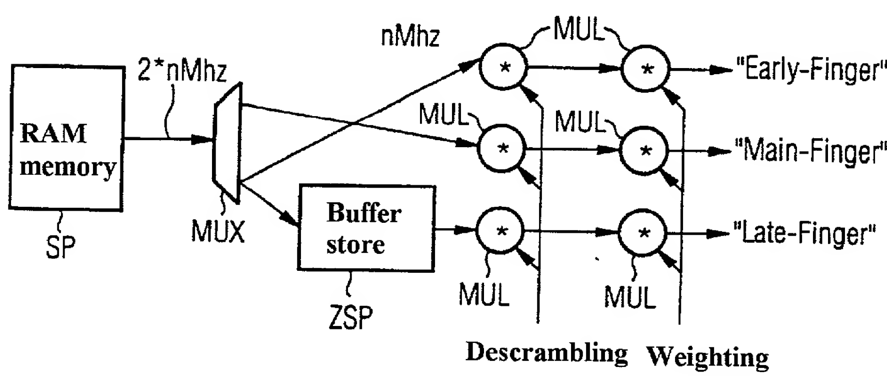

RAM memory
SP
3*nMhz
MUX
nMhz
MUL
MUL
MUL
MUL
MUL
MUL
"Early-Finger"
"Main-Finger"
"Late-Finger"
Descrambling
Weighting

FIG 10


RAM memory
SP
2*nMhz
MUX
nMhz
Buffer store
ZSP
MUL
MUL
MUL
MUL
MUL
MUL
"Early-Finger"
"Main-Finger"
"Late-Finger"
Descrambling
Weighting

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY
(Includes Reference to PCT International Applications) PCT/DE99/03430

ATTORNEY'S DOCKET NUMBER 112740-198

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name, I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD FOR CONTROLLING MEMORY ACCESS IN RAKE RECEIVERS WITH EARLY-LATE TRACKING IN TELECOMMUNICATIONS SYSTEMS

the specification of which (check only one item below):

☐ is attached hereto.

☒ was filed as United States application
Serial No. 09/830,624
on April 27, 2001,
and was amended
on ____________(if applicable).

☐ was filed as PCT international application
Number ____________
on ____________,
and was amended under PCT Article 19
on ____________(if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
Germany	198 49 532.3	27 October 1998	☒ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO

Combined Declaration For Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications) PCT/DE99/03430	ATTORNEY'S DOCKET NO. 112740-198

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject mater of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, Untied States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS		STATUS (Check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.

PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)			

POWER OF ATTORNEY: As named inventor, I hereby appoint the following attorney(s): Holby M. Abern (P47,372), Robert M. Barrett (30,142), Alan L. Barry (30,819), Thomas C. Basso (46,541), Jeffrey H. Canfield (38,404), Robert W. Connors (46,639), Amy J. Gast (41,773), Timothy L. Harney (38,174), Patricia A. Kane (46,446), Michael S. Leonard (37,557), Edward A. Lehman (22,312), Adam H. Masia (35,602), Dante J. Picciano (33,543), Renato L. Smith (45,117), Maurice E. Teixeira (45,646), William E. Vaughan (39,056), Austin Victor (47,154), and all members of the firm of Bell, Boyd & Lloyd LLC.

Send Correspondence to: **BELL BOYD & LLOYD LLC** **P.O. Box 1135** **Chicago, Illinois 60690**	Direct Telephone Calls to: 312/807-4292

201	FULL NAME OF INVENTOR	FAMILY NAME BRAAM	FIRST GIVEN NAME REINHOLD	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY 46414 Rhede	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Hohes Land 3	CITY 46414 Rhede	STATE & ZIP CODE/COUNTRY Germany
202	FULL NAME OF INVENTOR	FAMILY NAME NIEMEYER	FIRST GIVEN NAME ULF	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY 44803 Bochum	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Auf Dem Alten Kamp 33	CITY 44803 Bochum	STATE & ZIP CODE/COUNTRY Germany
203	FULL NAME OF INVENTOR	FAMILY NAME SKUK	FIRST GIVEN NAME OSKAR	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY A-1180 Wien	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Waehringerstr. 125/5	CITY A1180 Wien	STATE & ZIP CODE/COUNTRY Germany

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE 22.10.2001	DATE 22.10.2001	DATE

Combined Declaration For Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications) PCT/DE99/03430	ATTORNEY'S DOCKET NO. 112740-198

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject mater of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, Untied States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS		STATUS (Check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.

PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)	PATENTED	PENDING	ABANDONED

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201	FULL NAME OF INVENTOR	FAMILY NAME BRAAM	FIRST GIVEN NAME REINHOLD	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY 46414 Rhede	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Hohes Land 3	CITY 46414 Rhede	STATE & ZIP CODE/COUNTRY Germany
202	FULL NAME OF INVENTOR	FAMILY NAME NIEMEYER	FIRST GIVEN NAME ULF	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY 44803 Bochum	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Auf Dem Alten Kamp 33	CITY 44803 Bochum	STATE & ZIP CODE/COUNTRY Germany
203	FULL NAME OF INVENTOR	FAMILY NAME SKUK	FIRST GIVEN NAME OSKAR	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY A-1180 Wien	STATE OR FOREIGN COUNTRY OS 23/10/2001 ~~Germany~~ AUSTRIA	COUNTRY OF CITIZENSHIP ~~Germany~~ ITALY OS 23/10/2001
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Waehringerstr. 125/5	CITY A1180 Wien	STATE & ZIP CODE/COUNTRY ~~Germany~~ AUSTRIA OS 23/10/2001

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203 Oskar Skuk
DATE	DATE	DATE 23/10/2001

Combined Declaration For Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications) PCT/DE99/03430	ATTORNEY'S DOCKET NO. 112740-198

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PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS		STATUS (Check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (If any)			

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Send Correspondence to: BELL BOYD & LLOYD LLC P.O. Box 1135 Chicago, Illinois 60690	Direct Telephone Calls to: 312/807-4292

204	FULL NAME OF INVENTOR	FAMILY NAME FALKENBERG	FIRST GIVEN NAME ANDREAS	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY 58093 Hagen	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Weissensteinstr. 13	CITY 58093 Hagen	STATE & ZIP CODE/COUNTRY Germany
205	FULL NAME OF INVENTOR	FAMILY NAME ROHE	FIRST GIVEN NAME CHRISTOPH	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY 44793 Bochum	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Schmidtstr. 41	CITY 44793 Bochum	STATE & ZIP CODE/COUNTRY Germany
206	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

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SIGNATURE OF INVENTOR 204	SIGNATURE OF INVENTOR 205	SIGNATURE OF INVENTOR 206
Andreas Falkenberg		
DATE 5-Nov-2001	DATE	DATE

Combined Declaration For Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications) PCT/DE99/03430	ATTORNEY'S DOCKET NO. 112740-198

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U.S. APPLICATIONS		STATUS (Check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.

PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (If any)			

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204	FULL NAME OF INVENTOR	FAMILY NAME FALKENBERG	FIRST GIVEN NAME ANDREAS	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY 58093 Hagen	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Weissensteinstr. 13	CITY 58093 Hagen	STATE & ZIP CODE/COUNTRY Germany
205	FULL NAME OF INVENTOR	FAMILY NAME ROHE	FIRST GIVEN NAME CHRISTOPH	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY 44793 Bochum	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Schmidtstr. 41	CITY 44793 Bochum	STATE & ZIP CODE/COUNTRY Germany
206	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

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SIGNATURE OF INVENTOR 204	SIGNATURE OF INVENTOR 205 Ch. Rohe	SIGNATURE OF INVENTOR 206
DATE	DATE 16.10.2001	DATE